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THE THEORY OF PRODUCTION¹

Writing of the state of theories of production and distribution that were current from 1776 to 1848, Professor Cannan found it "not very easy to understand the admiration which was once felt for the progress made during that period."² In another part of the same work he calls attention to the "unsatisfactory character of theories of production and distribution regarded from a purely scientific point of view."³ Whether the theory of production or of distribution weighed more heavily in his scale of estimate, it is difficult to say. Whether, also, his disappointment with the progress of economic science in these fields was due to inherent doctrinal fallacy in the system of political economy he is reviewing or to the restricted scope of subject-matter which economic science set up for itself, it is likewise difficult to say. But it is clear that these two elements in scientific systems are not one and the same thing. For science may fail to meet current needs either because its laws or principles cannot stand the test of the accepted canons of formal logic or because these principles are based upon a restricted range of phenomena. A theory of production may, in other words, be true as far as it goes, but it may at the same time be practically useless because it does not go far enough. Scientific progress is effected, accordingly, not only by the refinement of old tools and the rearrangement of old material, but, to a much greater degree, by the fashioning of new tools and the addition of new material that requires explanation and formulation—in short, by widening the range of scientific inquiry. The recognition of this fact makes necessary from time to time the re-statement of the problems of a science in such a form as to permit a survey of the materials of science that have hitherto been neglected. In the light of these considerations, this paper addresses itself to an examination of the current theories of production.

I

That the price concept dominates contemporary economic theory is a truism. It is not altogether clear, however, what form this domination takes and what consequences in theory it entails. For the purposes of this discussion it is sufficient to say that thinking in terms of money units has created serious difficulties in the measurement of national income and wealth and in the interpretation of the facts of productive processes, and that the price paid for these difficulties is not

¹ This paper was read at the Thirty-third Annual Meeting of the American Economic Association held in Atlantic City, December 28, 1920.

² Cannan, *Theories of Production and Distribution*, second edition, p. 379.

³ *Ibid.*, ch. IX.

warranted by the returns in economic theory. Whether properly a part of economic theory or not, discussions of the magnitude and distribution of national wealth and income have for a long time held a prominent place in economic writing. Both lay and professional students of economic life want to know not only how industrial organization works but also what its practical effects are. Measures of wealth and income are ways of estimating the efficiency of the industrial organization of communities. They are barometers of material progress and of shifts in social control. And they are almost without exception constructed on the basis of money units. When expressed in absolute terms they are money aggregates and when expressed in relative terms they represent simply the relationships of the same aggregates to one another. Yet, widespread as this process of money measurement is, and useful as the results of inquiry into money measures may be, the fact remains that the initial results of industrial activity are physical goods and services—wheat, coal, locomotives, power generators, and light. And it is on the abundance or scarcity of such things that the material well-being of peoples depends. Now, it is conceivable that the relation between the physical output of a country and its money value is of so simple and constant a nature that conversion from one to the other is a matter of elementary arithmetic. This is in fact sometimes the case. But, for the most part, market phenomena in modern society are so complex that conversion is beset with technical difficulties almost insurmountable.

This difficulty appears in its simplest form where money wealth and income vary because of changes in the purchasing power of the prevailing unit of value. Thus, in the study of variations in wages, a form of income which is usually expended with great celerity, devices are employed to neutralize the influence of price fluctuations. Much time and energy have been expended in the construction of correction factors that are designed to bridge the span between money and goods. Index numbers of wholesale prices, retail prices, and of the cost of living—each, with all of its variants, has at one time or another served this purpose. Controversy over the validity of alternative devices of this nature still finds a place in the technical journals. But in this case the problem is comparatively simple. The incomes of individual laborers are relatively small; they are spent almost immediately after they are received; they are used to purchase commodities whose prices can, in a general way, be easily determined. What, however, is the instrument that should be used to correct changes in the money value of corporation surpluses? Should an income of one million dollars in a period of rising prices be converted from money to real income on the same

principle as that by which conversion is made of incomes under three thousand dollars a year?

From 1904 to 1912, the national wealth of the United States increased 75 per cent. Population in the same period increased 15 per cent and wholesale prices 17 per cent. Even if allowance be made for the rise in prices during this period, the wealth of the country shows a substantial increase. The question is, how far this increase in total wealth reflects itself in the material status of members of the community. According to Watkins, "some of this sort of increase in national wealth is doubtless due to more adequate occupation of national advantages, but more of it is of the nature of the increment in the value of the ground upon which New York City is built."⁴ That is, the money wealth of the country increased from 1904 to 1912, not through the creation of more goods and services, but through appreciation in land values. Nor is it easy to estimate with only a small margin of error the portion of the increment of wealth that originates from this source.

Another and more serious class of problems arises from the effects of the progressive utilization of the natural resources of a country and from changes in public policy that have a profound, if unknown, influence on the magnitude of national wealth. Enough is known of the system of valuation of public utilities in this country to permit the generalization that their advertised money value may bear little direct relation to their physical character. A private water company on the point of sale to a municipality will have one value; for the purposes of rate valuation it will have a second; as taxable property it may have a third; and the same physical property finally owned by the state may have still a fourth. By only the smallest stretch of the imagination, all of these stages of valuation may be conceived as transpiring within a period of two or three years. Yet the water company, the source of potable water to the community it serves, has probably experienced no significant change in its physical character at all. Programs of railroad valuation present the same kind of picture. Whether one or another of the several current theories of railroad valuation earns general acceptance, the railroads of the United States will at any one time meet the needs of the country, not by showing a higher or lower valuation, but by being able to furnish adequate and satisfactory transportation service. It is the second factor that counts.

Public utilities also exhibit the influence of a class of phenomena that probably widen the gap between money valuation and physical capacity and performance. The history of the public utility has been a story of

⁴ G. P. Watkins, "Estimated Valuation of National Wealth," *AMERICAN ECONOMIC REVIEW*, September, 1915, p. 689.

the progressive encroachment of the authority of the state on private control and ownership. If our customary conceptions of the profit motive are sound, this development must produce a profound effect on the money value of public utilities. But, whatever has happened to money value—and the material for answering this question is not available—the increment of public welfare is obviously a quantity of a different nature and a different order of magnitude from anything that can be reasonably measured in money terms. This is particularly the case when what was once private enterprise has passed completely into the control and ownership of an organized community. We have yet to develop a continuous system of money accounting that can accurately represent the value to communities or to individuals of property that has so changed hands. Conversely, the problem appears in no simpler form when the economic history of a country is such that, described in terms of well known economic categories, goods are constantly changing in status from free to economic goods. By all methods of measurement with which we are familiar, the national wealth would under such conditions increase. Only in the case of goods whose supply may ultimately be entirely exhausted, is it possible to register in money accounting the loss to a community from scarcity. But even in such a situation, the time when money wealth falls and the extent to which it falls are largely matters of speculation. This whole question is one of considerable complexity but its practical implications can be indicated in a question of this nature: "What effect, if any, will the impending exhaustion of our natural resource of crude oil exert on the next estimate of the national wealth of the United States?"

In all of this discussion the important point is that errors of one kind or another are likely to appear in estimates of national wealth and income. The errors are generally of such a character that neither their number nor their degree is calculable. The whole process is one in which a quantitative goal is being constantly shifted to allow for the influence of a range of variable qualitative factors. Those factors, furthermore, are usually not accidental in origin but are directly or indirectly based on some principle of economic or accounting theory. An estimate of the national wealth of a country is, for instance, a money aggregate composed of a large number of constituent money estimates. The determination of each of these constituents makes necessary one or more decisions with regard to content and magnitude and the resolution of all of the difficulties that such decisions involve. Hence the larger the number of decisions required, the more complex the raw material, the greater will be the range of error. Nor is it practically possible to make any but the roughest and most useless allowances for errors of this nature. For most estimates of this kind

rest upon a great deal of implicit economic and accounting theory and an insignificant amount of explicit theory. One reviewer of a census estimate of national wealth left "his task with a strengthened feeling that economic statistics must be as much economics, even theoretical economics, as statistics." "It would do no harm," he said, "for the Census Bureau to make its theories explicit."⁵ A commentator on King's study of wealth and income, while expressing great admiration for the study, lamented the absence of the detailed data from which the validity of the totals might be tested.⁶ Given, therefore, an unknown factor of this nature as a pervasive component of all estimates of national wealth, and the difficulty of making sound judgments, for the purpose of accepting or rejecting the conclusions of the study, should be evident.

II

Money estimates of national wealth, then, involve logical leaps and methodological assumptions that dictate their use with the utmost of caution and circumspection. But the measurement of wealth in terms of money is only one manifestation of a universal practice which underlies organized economic thinking. And it is to the more subtle and indirect influences of a pecuniary economic theory that our attention should turn. Men and women, in contemporary economic life, may be described as leading double lives. They live, on the one hand, in the market place, bargaining for wages, bread, stocks and bonds, locomotives, and what not; and, on the other hand, they live in factories, stores, offices, and farms, where they are machine tenders, hand operatives, managers, promoters, and clerks. If some of the energy of modern men is expended in the function of bargaining, or valuation, certainly a far greater amount is consumed in the processes of invention, management, and manual labor. Yet, so profoundly has the study of market phenomena and price determination directed scientific economic thinking, that technological and psychological phenomena, fundamental in more ways than one to a proper understanding of the machinery of production, have been almost wholly neglected. The meas-

⁵ G. P. Watkins, *op. cit.*, p. 689.

⁶ "It is to be regretted that Mr. King has not taken his readers more into his confidence in respect to these and other details of the methods he has used. He indicates his source but does not explain all of his estimates. It is impossible to verify his results except by doing his work over again from the beginning." Allyn A. Young, *Quarterly Journal of Economics*, May, 1916, p. 582. It is interesting that in the same review, Professor Young characterizes the book as "Free from irrelevant and insignificant detail, it represents a courageous and painstaking attempt to get at the larger facts in the situation." What are the "larger facts" as separate and distinct from "irrelevant and insignificant detail"?

urement of progress in terms of money and the development of an economic theory in almost the same terms have had the effect of directing emphasis and of throwing light on one class of economic phenomena and of leaving another in partial obscurity. Wherever, in the prevailing theories of production, the attempt has been made to consider technological and psychological factors, the results have been formulae of the utmost simplicity and generality which may be summed up in the familiar expressions "division of labor" and "diminishing returns."

Nor is this emphasis on the market place limited to the thought of professional economists. It permeates popular thinking as well. Whether the likeness between professional and lay opinion is a phenomenon of cause and effect, it is difficult to say. But that it exists there is no doubt. Mitchell's description of the situation designates not only the bare facts in the operations of a pecuniary economy but also the nature of human reactions to the facts. "The economic comfort or misery of a modern family depends not upon its efficiency in making useful goods and its skill in husbanding supplies, but upon its ability to command an adequate money income and upon its pecuniary thrift. Even in years when crops are short and mills are idle, the family with money need not go cold or hungry. But the family without money leads a wretched life even in years of abundance. To the single family, then, prosperity and depressions appear not as problems of the adequacy of the goods produced, but as problems of the adequacy of money income." The accuracy of this statement needs no confirmation. Whether popular attitude preceded scientific formulation or vice versa may be a debatable question. But that in both spheres of thought the pecuniary attitude is the dominant one, there can be no reasonable doubt. In a very indirect, but at the same time in a very real and effective way, this manner of regarding economic activity is probably at the bottom of some of the restrictive practices of organized groups of workmen. But it is not within the province of this discussion to spread propaganda calculated to dissipate this common error. The task here is the far simpler one of pointing out that the limits of economic science, particularly in the treatment of the theory and facts of production, have been harmfully restricted by the influence of the pecuniary point of view. Because of this influence technological and psychological phenomena have been subordinated to those of the market, and inadequate theories of production have gained currency. From the standpoint, therefore, of both economic theory and economic measurement, the dominance of a money attitude has had the effect of diverting investigations from fields in which the scientific yield should be very high indeed. That investigators in these un-

¹ Mitchell, *Business Cycles*, ch. II, p. 21.

worked fields will meet new and unfamiliar problems is true. But the fear that the problems they will meet are insoluble will deter only the timid.

III

What types of problems, then, would more complete theories of production comprehend? The first step in the extension of the theory of production is the clear recognition of the place in theory of technological and psychological facts. Production may, from one angle, be considered as a synthesis of the contributions of managers, workers, and inventors. It is the function of political economy to be aware of these contributions; to know the conditions under which such contributions are advantageously made and the conditions under which they wither. Competent description of this kind of knowledge can be accomplished only through the medium of a relevant terminology. Money units are not specifically and directly relevant either to technological or psychological phenomena. So for the purpose of describing such phenomena, money units must be discarded.⁸ Once economic material is collected and organized from that point of view, discussions of the nature of production should assume another and more realistic form. Industrial history would then be not only an account of financial organizations and reorganizations, of price and wage movements, of financial and business crises, enlivened by incidental remarks on outstanding inventions and inventors, but also the story of the technical progress of industry. The history of the successive steps in the utilization of water power may not lend the romance to economic history that it deserves; but it cannot be doubted that an acquaintance with the course of water-power development is, at least, as essential to the intelligent understanding of economic progress as a knowledge of world changes in the output of gold. And what is true of a knowledge of the use of water power is equally true of the knowledge of a great mass of other technological developments.

Practically from the beginning of systematic political economy, the relevance of discussions of invention in theories of production was recognized. Except, however, for the observations of Adam Smith and the criticisms of Jevons, economic treatises are surprisingly barren of any adequate treatment of the course of invention. Here and there, stray facts appear, some new and some old, but progress in theory is painfully absent. And yet the problems of invention, in so far as they

⁸ By this I do not mean to question either the importance or the necessity of the analysis of price mechanisms and institutions. But I do mean that, for the purpose of explaining the kind of economic facts which I am here treating, the study of market processes and of prices has failed to provide illumination.

concern economic theory, are susceptible of systematic statement and probably of satisfactory solution. This gap in economic theory, like others of the same nature, is probably not due to any unusual difficulty in the problem but to an almost patent disregard of it. For the purposes of orderly treatment a theory of invention resolves itself into three or four constituent elements.

The first of these is concerned with the personality of the inventor. It seeks to answer the questions: "What kind of people are inventors?" "What are the conditions under which inventors invent?" On this point there has already been some discussion and inquiry. Interest in the question has turned on the place and influence of the pecuniary motive on the productivity of inventors. There seems at the present time to be no serious difference of opinion with regard to the existence of other stimuli that produce the kind of intellectual activity that leads to invention. But the real debate apparently centers on the question whether these stimuli (instincts of workmanship, contrivance, or creative impulses) are primary and dominant or secondary and subordinate; whether, that is, inventors would invent as freely as they do now without having always before them the prospect of economic gain. That the pecuniary motive is the significant one has for a long time been the tacit, if not the expressed, economic doctrine. But even the slightest survey of economic literature shows that, where the question has really been studied, differences of opinion have appeared. Tausig, for example, finds that "the social and economic structure being what it is now, and men being now under its influence, they are not likely to exert their powers for the general good unless guided, stimulated, and rewarded in much the same way as leaders in other forms of creative activity."⁹ Marshall, on the other hand, is not so sure on this point. "An improvement in business method," he writes, "is generally initiated by a man of affairs who sets himself to attain a particular practical end by the best route. The same is generally true of advances in industrial technic, in so far as they are made in the course of business; but the greater part of the work which lies at the bases of these advances is made by other men with different motives and different methods. It is made by mere students; that is, men who labor, not with reference to the attainment of any particular practical end, but in search of knowledge for its own sake."¹⁰

Now, it is true, as Tausig says, that "on these topics we are much in the dark." But that our ignorance is due to "the same cause that prevents decisive answers to many economic questions," namely, that

⁹ F. W. Tausig, *Inventors and Moneymakers*, p. 54.

¹⁰ Alfred Marshall, *Industry and Trade*, p. 203.

"we are unable, or at least unwilling to experiment with ourselves,"¹¹ is not so clear. At any rate, the problem is one that can be investigated with a hope of creditable, if not revolutionary, results; and economic dicta with regard to the matter can be removed from the realm of pure speculation to one of experience. An important beginning in this direction has already been made by Taussig in his study of the lives of a group of great inventors. What remains to be done will involve both the accumulation of the historical records of the reactions of inventors to their economic milieu and careful contemporary observation. The material for a more complete theory of this phase of invention cannot and, fortunately, need not be confined to that which may be obtained from formal biographical records. For the last few generations and perhaps earlier, inventors, in their relations to the industrial order, have made their contributions to the progress in the arts under varying conditions. It is in an analysis of these conditions and of the character of the contributions made under their influence that a part, at least, of the answer to our question should be found.

Disregarding, for the moment, brilliant individual inventors who work in isolation and who unaided plan, perfect, and exploit their own inventions, it may be said that much of the contemporary contribution to progress in the industrial arts originates in the technical and research divisions of private businesses and in the research laboratories of government bureaus and of universities. An increasing proportion of the great industrial enterprises in this country have organized as an integral part of their business large and continuous research divisions whose function it is to point the way to improvements in industrial technic. Depending on the nature of the industry, mining engineers, chemical engineers, chemists and physicists, agricultural and industrial chemists, rub shoulders daily in the quest for technical discovery. What factors determine the problems on which this army of scientists is put to work? What is the relation between the importance of their discoveries and the pecuniary reward they receive? Are discoveries in institutions of this character sporadic and revolutionary, or are they gradual, slow, and cumulative? These are types of questions on which a well informed opinion concerning the origins of invention must rest. The records for answering these questions are there. It is necessary only to study them. While it may be argued that problems of this nature are intricate and hence difficult, it is doubtful whether their intricacy is any greater than that encountered in studying other aspects of modern business phenomena. American economists, for instance, have always wanted to understand and explain the policies of

¹¹ Taussig, *op. cit.*, p. 19.

American trade unions. A knowledge of trade union policy assumes an acquaintance with human acts and attitudes of the utmost intricacy and obscurity. But the mere difficulty of the question has not stopped the search for light.

Alongside these men who apply their science in the laboratories of private business are the many public servants who are engaged in the same kind of pursuit under different auspices. In the Department of Agriculture a corps of men with scientific training spend their time in the public service on problems of agricultural technic. Similar groups in the Bureau of Mines and the Bureau of Standards do the same kind of work on problems of technic in other fields of industrial activity. And so on, throughout the whole structure of federal and state government in this country, there are thousands of men and women so engaged. Now there must necessarily be certain important points of likeness and of difference in the operation of these two systems of scientific investigation. Perhaps the men employed in public agencies are of a lower order of competence, or vice versa. Perhaps the discoveries made in private laboratories are applied more promptly and more efficiently to the machinery of industry than those made under the public control. It may, indeed, very well be that the needs of practical industry are so much more clearly known to the manager of the private research bureau that there he avoids all of the wastes of indecision and ignorance, and moves with his co-workers swiftly to the goal of his inquiry. Whatever the actual facts in the situation may be, here is obviously much food for thought and much material for political economy. On the face of the matter, too, it does not seem fantastic to ask for a comparative study in public and private research bureaus of the frequency, originality, brilliancy, and practicability of the discoveries made in each.

The field of comparative study may, indeed, be widened by introducing a third variable, namely, the conditions of discovery in the laboratories of universities. It is not difficult here to find men who have devoted their lives to search for truth; the pecuniary motive, if it functions at all, is far in the background. The university investigator, further, works apparently under conditions that are remote from the practical phenomena of industrial activity. He is regarded as having a detached and uninterested attitude toward the practical problems of economic life. This feeling about the university scientist is strengthened by an open lack of interest in him for the so-called applied science—the chemistry of perfumed soaps. It is frequently the guild principle among some scientific faculties that the task of their members is the pursuit of knowledge for its own sake. Now where this is true, what is the nature of the scientific output? Does the pursuit of pure science,

for its own sake, promote or retard invention as applied to industry? What, in other words, are the differences and similarities between the discoveries of university investigators and those of public and private servants? Can it be that the great basic discoveries which make possible the later progress in the industrial arts originate within the walls of our universities? Or are they the product of the well-equipped and efficiently organized laboratories of private business?

It should, of course, be clear that, in our present state of knowledge, it is impossible to present definitive answers to the questions we have raised. All that we can hope to do now is to find the problem, formulate it, and estimate its importance. But it may be well to call attention briefly here to observations on the same questions made by one or two economic students of the same problem. In an acute discussion of the conditions under which technical progress in industry takes place, Marshall not only recognized the existence of what we may call large-scale research and inventions but suggested the effects that the growth of such institutions might have on our traditional conceptions of motives. In some measure, he writes, "the world is saved by the influence of motives other than the desire for gain. To begin with, the increase in the size of industries is often accompanied by the substitution of scientific methods for empirical; while a sound basis of scientific technic is largely provided by laboratory work, to which an ever increasing number of elastic and enterprising minds are rising from among the people; being stimulated a little by the hope of gain, and much by intellectual ambition, and the sympathy of other students of science. . . ."¹² Similarly, much earlier, John Rae made in this very connection the interesting and pertinent suggestion that the motives that promote discovery and inventions, applicable to the industrial arts, are probably of the same nature as those that move men in the pursuit of pure science.¹³

The possibilities of a theory of invention are, however, not exhausted by the consideration of the incentives to inventors and discoverers. Of equal, if not greater, importance in the theory is the statement of the

¹² Alfred Marshall, *op. cit.*, p. 325.

¹³ "Our subject leads us to attend to invention merely as it concerns itself with the material world. But, as the motives exciting the men in whom it is exhibited to give themselves up to its requirements, must be held among the chief of the causes of its manifestation, and as they who in this department have been most extensively inventors, have in general communicated little of the principles that animated and sustained them in their career, science and art being silent of themselves, we may be allowed to give wider compass to our view, and to cite, when our purpose requires it, those who have been real discoverers in any of the various regions over which the power of this principle extends." *The Sociological Theory of Capital*, edited by Charles W. Mixter (1905), p. 132.

history of an invention after its discovery. It is a fact of common observation that only a very small proportion of the total number of scientific discoveries and inventions find practical application in industry. Some inventions are, no doubt, impracticable in every sense of the term. But is it generally true that suppression or exploitation of inventions in this country is dictated by a uniform business and industrial policy, the character of which is understood by economists and the effects of which on economic development are known by them? The probability is, rather, that business practice in this regard varies considerably from business to business, from industry to industry, from time to time. If our experience with this question exhibits a modal character, the nature of the mode still remains to be explained. One of the very striking business developments of the last generation has been the organization of great corporations whose primary function has been the exploitation and control of new machines. Such corporations are the United Shoe Machinery Company and the Owens Glass Bottle Blowing Machine Company. In organizations of this character are vested usually all of the rights to the machine and out of this control grows the power to determine the conditions under which the machine may be used. In the proper exercise of such power both the general public and inventors are intimately concerned; the general public because the policy of utilization has a direct and far-reaching effect on the performance of an industry which supplies its needs, and the inventor because the policy may result in the extension or in a complete restriction of his sphere of usefulness and activity. The enormous practical importance of this whole question has always been recognized with reference to the policy of organized labor. Opposition of trade unions to the introduction of machinery and restrictions of trade unions on the full use of machinery are universally considered in economic treatises. But the more fundamental practices of business in the same direction have received neither as competent nor as extensive treatment.¹⁴

A third phase of the invention problem is the relation between invention and patent legislation. An analysis of the character and effects of patent legislation should throw light not only on the influence of certain types of legislation upon the utilization of the fruits of invention but also on the incentives that motivate inventors. A recent student of the practice of suppression and non-working of patents finds

¹⁴ Studies by Professor George E. Barnett on the relation between the introduction of machinery and trade union policy are admirable exhibits of what research can accomplish in this field. See, for instance, his "Introduction of the Linotype," *Yale Review*, November, 1904; and "The Stonecutters' Union and the Stone-Planer," *Journal of Political Economy*, May, 1916. He has made also similar studies in other industries but these have not yet been published.

that the purchase and suppression of patents in this country promotes monopoly and also "discourages invention and retards industrial progress. . . ." He quotes a statement of the Inventors' Guild to the effect that "modern trade combinations tend strongly toward constancy of processes and products, and by their very nature are opposed to new processes and new products originated by independent inventors, and hence tend to restrain competition in the development and sale of patents and patent rights; and consequently tend to discourage independent inventive thought. . . ." This is, of course, an *ex parte* statement. But it is significant that the same writer leaves his discussion of this charge with the conclusion that "it is difficult to find specific evidence with which to prove this practice, as no general intensive investigation of it has ever been made."¹⁵ It is one of the functions of political economy to organize inquiries that attempt to supply the necessary evidence.

IV

While the first formulations of a scientific theory may contain all of the elements essential to the proper development of that theory, later influences may direct attention from these elements and thus limit the content of the theory. This is apparently what happened to the theory of production. Thus Cannan wrote some years ago that "a discussion of the different circumstances which regulate the amount of per capita produce is exactly what we should expect to find in a theory of production."¹⁶ And by this demarcation of the field, such a question as invention would find a respectable place in it as one of the "circumstances which regulate the amount of per capita produce." A second, and by no means less important, circumstance affecting the amount of per capita produce is the attitude of the worker toward his work. Traditionally this question has been treated as a problem in the incentives to economic activity. When the industrial machine is working smoothly and the rate of individual output seems to be reasonably high, the factor of incentives is regarded as having little theoretical or practical importance. But when, as during the past three years, the need of increased production appears, attention is centered on devices for stimulating men to work. Nevertheless, even in periods of the first kind, a science of economics, dealing as it does largely with the motives and acts of men, must build its principles upon a foundation of psychological observation. This necessity political economy has met in the past with a substratum of psychology characterized by extreme simplicity

¹⁵ Floyd L. Vaughan, "Suppression and Non-Working of Patents, with Special Reference to the Dye and Chemical Industries," *AMERICAN ECONOMIC REVIEW*, December, 1919, p. 693.

¹⁶ Cannan, *op. cit.*, p. 36.

and uniformity. Human nature it regarded as simple, and everywhere and at every time the same. Differences between men are external and ephemeral; similarities, deep-rooted and dominant. The mainsprings to economic activity were so well known that they could be and were reproduced in tables, in which motives or incentives were arranged in order of magnitude or strength. Such precision, of course, has its influence. If political economy consists of a body of economic principles, and if these principles rest in turn upon a fund of psychological observations, then the more certain we are of the truth of our psychological observations, the readier we are likely to be to accept the economic principles.

The psychological data on which economists built their systems are now being frequently and successfully challenged. While there is yet no complete psychological system to replace the one now in use, the observations of contemporary psychology are such as to indicate that motives are more complex and more variegated than the economists assumed. Attempts to revise political economy with reference to later psychological notions are now being made. In this neglected field brilliant contributions have already been made by Veblen, Mitchell, and Carleton Parker. It is unfortunate, however, that some of the large and important currents of economic thought have remained untouched by these developments. The psychology of the bulk of political economy is still the fruit of limited personal observation and of a species of introspection. When we remember that the contact of the average economist with many of the realities of economic life is slight and infrequent, then we may be pardoned for doubting that he is a representative type of economic actor and for doubting, therefore, that his contemplation of himself will produce a representative and reliable psychology.

Probably nowhere in economic writing has this failure to recognize the complexity and diversity of human nature brought results that more clearly need revision and restatement than in American studies of organized labor. Under the implicit influence of an economist's psychology, the American labor movement has acquired for the science of economics a homogeneity and uniformity which it probably does not possess at all. Not that there are not important and outstanding points of similarity in the movement; but that there are at the same time marked differences, and for purposes of understanding and explanation the differences are at least as real and as efficacious as the similarities. What there is of a labor movement in the South, for instance, is in many of its characteristics quite a different thing from the labor movement in New York City; and west of Chicago it is as different from that in New York as the movement in New York is from that in the South. Within the same geographical limits, also, the contrasts

are as striking as the points of agreement. One need only compare trade unionism in New York in the needle trades with that in the building trades; trade unionism in Chicago among the teamsters and chauffeurs with that in the packing houses. The existence and influence of types of trade unions were recognized and described by Hoxie; but the whole problem still presents a virgin field for further study. Economists must admit within the phenomenon of organized labor the existence of types of human behavior. The next stages in the investigation of trade unionism may with much profit be concerned with studying patterns of behavior; with relating these patterns to the technical organization of the industry in which members of the union work; with the financial and industrial policy of the business; with the conditions under which the workers live; and with the better known hereditary and environmental influences that are usually regarded as shaping the conduct of men. The program of research outlined with reference to this restricted field of economic activity should be no different in its essential details from that to be followed in discovering the cause and nature of economic behavior under other conditions. Economic life, in its largest sense, may be conceived as a mass of complex situations. Among the many factors that are responsible for creating economic situations, certainly two are always active. These two factors—technology and psychology—act and react upon one another. It is impossible to conceive scientific progress without a painstaking and detailed study of both.

V

No analysis of the prevailing economic theory of production is complete without the consideration of such elements of the theory as have been the subject of inquiry but where physical and technological factors have not received the attention they deserve. The problems of the utilization of natural resources and of the localization of industry answer this description. Each is a problem that has its technological side. Political economy has treated both problems; but the terms of its treatment have been general, and it has failed to bring to bear upon them pertinent technological material. The gaps, in this case, must be filled with facts about business practice and with evidence designed to test the soundness of our generalizations. The foundation of the economic life of the United States consists of an enormous reservoir of natural resources—plant, animal, and mineral. The well-being of the community depends upon their effective and restrained utilization. Whether or not the people of a country receive to the full the benefits which should come from the possession of natural resources depends upon the degree to which business practice recognizes and accepts the

limitations imposed by the natural or technological characteristics of the resources. In economic writing, analysis of the problem of natural resources has been limited almost entirely to pointing out the relation between a growing population and the inevitable exhaustion of material resources. The implication is that the rate of depletion is a function of the rate of growth of the population. Hence the rate of fall in the average standard of living in a country is also, after a certain point of development has been reached, a function of the rate of growth of the population. But scientific theory does not gain strength and conviction by being general and vague in its terms. The more specific its observations, the greater its body of supporting evidence, the more reason there will be for accepting its principles and generalizations.

Engineering art and technological science have only within the past decade accumulated and interpreted a vast body of material with regard to natural resources. The contributions from these sources are important in that they indicate, first, the availability of substitutes for various classes of natural resources, and, second, that they describe the wastes due to unregulated exploitation both in the early and late stages of the processes of industry. With such resources as coal, crude oil, timber, the history of depletion has not been the simple one of the encroachment of a growing population on limited reserves; but the situation has been overcomplicated by the injection of a set of business motives and practices that also have had their effect on the rate of exhaustion. These motives and practices, sometimes due to ignorance of scientific methods, sometimes to the mad desire for temporary advantage, constitute influences which no representative system of political economy can afford to ignore. In very much the same way, business practices and customs, almost independent of changes in the size of the population, are represented as leading to waste in industrial consumption at stages in the industrial progression far removed from the natural resources themselves. Recent studies by mechanical engineers of the technology of coal, for instance, point to wastes in production and consumption of coal beyond all imagination. The elimination or reduction of these wastes can only be accomplished by a study of the economic causes from which they originate and the economic situations in which they thrive. The existence of natural resources is an economic fact; their depletion is also an economic fact. All of the situations, customs, practices, motives, that determine the nature of the exploitation of the resources are, like price control, speculation, industrial combination, and so on, the materials with which an economic science must work. It is not enough to say that natural resources tend to become exhausted and that exhaustion follows increases in the population. We must go farther and analyze the conditions that are responsible for

rapid depletion and ultimate exhaustion. Is it too much to ask of economic theory that it estimate for us the cost, in any terms, to present and future generations of exploiting our natural resources at a rate much slower than the actual one?

In very much the same way as business custom and practice involve waste as well as efficiency and advantage in the use of material resources, the movement from one place to another within a country of business and industrial establishments similarly produces waste and expense as well as benefit and gain. If the development of transportation facilities permits the fuller utilization of geographical advantages and superiorities, it is at the same time true that railroad-building and ship-building are costly. The underlying assumption of economic theory in this regard has always been that the gains outweigh the costs. In an automatic way, industry becomes localized in one place rather than in another because of the operation of one or all of the following factors—proximity to raw materials, availability of power and transportation facilities, the presence of auxiliary industries and of capable and trained labor. If this be a true analysis of the major forces that have stimulated the building of industries in the places in which they are now found, then the advantages of the present and future localization of industry are what they have always been assumed to be. Indeed, however great these advantages may be they would redound to the benefit not only of enterprisers but also to that of the general community.

But on what specific evidence does this theory of localization rest? Is it an explanation after the fact or a statement of the advantages that accrue one, ten, fifty years after settlement of an industry in a new situs has taken place? May it not, indeed, be that to an unknown degree the kind of localization of industry which we see has thrown on the general community a burden of direct and indirect cost for which there has been no proportionate return in benefit? Throughout the whole development of rail transportation in this country, factors making for increase in cost have generally been operative. Considered in simple terms, any railway rate structure which was not based on the factors in localization enumerated above would produce a localization of industry that, in its origins, at least, would not satisfy the needs of a program of economical national development. Yet the local favoritisms incident to the railway history of this country are matters of common knowledge. In quite the same way, the general competition among American municipalities for factory and business settlements involves those communities in costs which they do not see but which are nevertheless real. Reduction in the tax rate to new manufacturing enterprises may constitute a legitimate aid to localization, but it can-

not be so considered until its further consequences are known. Migrations by manufacturers to escape labor conditions imposed by trade unions exhibit the same kind of conflicting evidence. The chronicle of such movements for the purpose of deriving the advantages of an available supply of labor is an old one in economic history. The clothing industry in England is placed where its leaders can use as labor the wives and children of dock laborers. The wives and children of American miners are the magnets that attract the textile mills in this country. And in the present migration in the clothing industry from cities to rural settlements, similar forces operate. That localization of this character contributes to the general level of well-being is a gratuitous assumption that is certainly open to question.

The question is all the more valid when we reflect that the change of situs is dictated not by economic considerations alone, but by a combination of economic and "moral" principles that are very hard to disentangle and to weigh. If such influences as these are at all universal, much of the localization of industry we are acquainted with cannot be satisfactorily explained in terms of arithmetic formulae of geographical diversities. For there resides in the condition of localized industry much that is artificial and deliberate, much that is due to the purposeful adoption of one economic policy as opposed to another, as well as much that results from the free and unimpeded operation of pure economic forces.

VI

If what has been said concerning the insufficiencies in the theory of production carries conviction, we should agree that economic theory must open its doors to the psychological and technological material that will shed light on its problems. The admission of such material and analysis of it by means of a relevant terminology should have not only theoretical but important practical bearings. Nowhere is this clearer than in the contemporary practice of wage adjustment. If, in this confusion of wage principle and practice, any theories of wages at all seem particularly to challenge attention, they are the theories contained in the expressions "standard of living" and "the ability of industry to pay." In the highly organized industries, in which the employer and working forces are more evenly balanced, wage adjustments are more and more being made with reference to one or another of several standards of living and to the ability of the industry to stand a further increase in wages. With regard to both measurement and theory, it is becoming increasingly difficult to make decisions without invoking material not yet found in traditional economic writing. The leap from one part of an economic text, where the national dividend

is described as a flow of physical goods and services, to another, where wages, rent, and interest are described as \$30 a week, \$500, and 6 per cent per annum, raises questions which arbitration boards and negotiating bodies cannot dodge. There is, in the first place, the simple fact that "standard of living," assumes a real meaning only when it can be expressed in terms of physical and nutritional units. In fact, during the past five years types of standards, so constructed, came widely into use, principally because standards expressed in money units did not throw that direct light upon human needs and comforts which an intelligent consideration of the question required. But if there is any advantage in the use of such a physical standard, it is most likely to be derived from a comparison between that standard and the capacity of the whole of industry to meet it. Such a comparison, of course, our present system of money accounting does not pretend to make. Another angle of the same problem appears in even a more interesting form in the attempt to determine the ability of a single industry to assume a specific wage scale. At first the discussion was altogether in terms of money wages, prices, and profits. But in the English coal mine adjustments, while the same elements still remained, the scope of the inquiry was soon widened to include material on the per capita output of miners, the total product of the British coal mines, the internal and external coal requirements of the country, and the factors responsible for variations in output. Without a consideration of these factors, intelligent settlement of the dispute would have been impossible. Simple as it may seem on its face, the whole procedure is revolutionary in that it makes possible the admission as economic evidence of a whole new range of economic fact, hitherto inadmissible. The English coal mining industry was, of course, at the time under arraignment, and the nationalization issue was in the air. But there is evidence that the same kind of tendencies are already at work in this country in connection with industries that, as yet, show none of the earmarks of public utilities.

It may, however, be argued that interesting as these problems are, the material with which they can be solved does not exist. The reply is, that here, as elsewhere, scientific material is not at hand until there is someone prepared to use it. The whole experience of statisticians and economists in Washington during the war pointed to the existence and availability of facts about industry the reality of which will never be admitted except by those who worked with them. No one would say that the need for an index of physical production is any more real and urgent today than it was ten years ago. Yet with practically no new material, the recognition of the problem has produced, first, the measure

of national production by Mitchell in 1919, and, second, extensions of the same device by Stewart and Day at the present time.

The task outlined in this paper may seem to be a job of a large order. It is. But in its essential character it is no different and no more arduous than that which always confronts the builders of any science. The work of Galton and Pearson, Davenport and Pearl in biological science produced in that field results as revolutionary as any that may be proposed in economic science. Not only was the problem in biology one of admitting new material, but there was also the further necessity of providing biologists with the technic of mathematical statistics. The development of biometrics finds its counterpart in the profound changes that the science of chemistry has gradually experienced. With the rise of physical chemistry, and the hypotheses of colloidal chemistry, the limits of chemistry were extended and the essential elements in the personal equipment of chemists were forced to keep pace. In political economy the matter seems no different. Formal delimitation of the scope of the science cannot be defended unless it results in positive, concrete, scientific advance. It may be convenient to know precisely what the limits of the theory of production are. But if the knowledge and the practice lead to sweet contentment and nothing else, the wisdom of the limitation may well be questioned. It has become customary, unfortunately, to lead the graduate student in economics through a first minor in history and a second minor in political science; or vice versa. This regimen has created a definite attitude toward the character and content of economic theory. To satisfy the new demands of the science, the course of training may have to be changed, just as it has been in other fields of knowledge, to enable the investigator to collect and interpret another type of material. With a background of psychology and technology, the future economists will enter an unploughed field, full of promise and hope for economics as a science.

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